

## Project Summary

### **Intellectual merit of the proposed activity**

Neutrinos are fundamental constituents of our universe but they are still relatively poorly understood. In the last decade remarkable progress has been made in this area which significantly altered our understanding of the neutrino sector. Even though the current generation of experiments will further elucidate this field many more questions will remain, especially in the area of the pattern of neutrino masses and mixing. More specifically, the key questions that will need to be addressed are what is the mass hierarchy of the neutrinos, what is the value of the third, as yet unmeasured, mixing angle, and is there matter/antimatter (CP violation) in the neutrino sector.

The key to further progress is a more detailed study of neutrino oscillations, specifically the detection of the  $\nu_\mu \rightarrow \nu_e$  transition associated with the atmospheric mass scale, whose rate is controlled by the currently unknown mixing angle  $\theta_{13}$ . Our collaboration would like to pursue these studies with the NuMI neutrino beam and a new detector placed on the surface at an off-axis position at a distance from Fermilab comparable to MINOS distance. The first phase of this work would involve a 50kt low density detector; in a five year run with a  $\nu_\mu$  beam we should be able to obtain sensitivity to the  $\nu_\mu \rightarrow \nu_e$  oscillation mode about 20 times better than the current limit.

This proposal requests support for R&D work whose eventual goal will be construction of a relatively small scale detector, based on identical technology as the one to be used for the principal detector, and using same granularity. This detector would not only be a prototype for the 50kt detector but also serve as the near detector for the experiment and allow us to do non-oscillation physics with a fine grained detector in parallel with the MINOS run.

The proposed R&D will consist of simulation work, bench hardware tests, exposures in test beams and cosmic rays and eventually construction of a prototype detector. The technology being proposed for this detector is well tested and its suitability does not depend on any new scientific invention. Thus the focus of the R&D will be more in the engineering area, to obtain a design that will provide the required reliability, to understand the relevant issues connected with the construction of this rather large structure, and to minimize the costs. The simulation work will emphasize finding parameters that maximize physics per unit cost. The test beam and cosmic ray work will be used to verify the performance of the detector in actual experimental conditions.

### **Broader impact of these activities**

The proposed experiment addresses many key issues which are of prime importance not only in physics but also in astrophysics and cosmology. Thus for example it addresses the mystery of the matter-antimatter asymmetry in the universe and thus the results may have profound impact on our general understanding of the universe.

We plan to take advantage of the public interest in these general questions to develop an associated outreach program at the detector site to inform public about the goals of scientific research in general and neutrino physics in particular. The R&D work being proposed will be carried out at several universities and will provide opportunities for local outreach programs and involvement of undergraduates in this work. We also plan to get high school teachers involved in this effort as much as possible.